

WE CLAIM:

1           1. A method for producing a germanium oxynitride layer on a Ge-based material,  
2           comprising the steps of:

3                     incorporating a first concentration of nitrogen into a surface layer underneath a  
4           first surface of the Ge-based material; and

5                     inducing growth of the oxynitride layer by exposing the first surface of the Ge-  
6           based material to an oxygen containing ambient, wherein the first concentration of  
7           nitrogen in the surface layer is controlling the growth of the oxynitride layer.

1           2. The method of claim 1, wherein the produced oxynitride layer has less than about 6nm  
2           of equivalent oxide thickness (EOT).

1           3. The method of claim 2, wherein the produced oxynitride layer has between 0.5nm and  
2           5nm of EOT.

1           4. The method of claim 1, wherein the Ge-based material consists essentially of Ge.

1           5. The method of claim 1, wherein the step of incorporating the first concentration of  
2           nitrogen is carried out by subjecting the first surface to a nitrogen containing gas under  
3           thermal conditions.

1 6. The method of claim 5, wherein the nitrogen containing gas is  $\text{NH}_3$ .

1 7. The method of claim 6, wherein the thermal conditions are selected to be a temperature  
2 between 450°C and 700°C applied for between 1 second and 300 seconds.

1 8. The method of claim 1, wherein the step of incorporating the first concentration of  
2 nitrogen is carried out by ion implanting a nitrogen dose into the first surface.

1 9. The method of claim 8, wherein in the step of ion implanting the nitrogen dose is  
2 selected to be between about  $1\text{E}15$  per  $\text{cm}^2$  and  $2\text{E}16$  per  $\text{cm}^2$ .

1 10. The method of claim 9, wherein in the step of ion implanting an implantation energy  
2 is selected to be between 0.5KeV and 10keV.

1 11. The method of claim 9, wherein the step of ion implanting is carried out through a  
2 screen layer.

1 12. The method of claim 1, wherein the step of incorporating the first concentration of  
2 nitrogen is carried out by subjecting the first surface to a nitrogen containing plasma.

1 13. The method of claim 12, wherein the nitrogen containing plasma is being applied with  
2 a power of between about 25W and 1000W, at a temperature of between about room  
3 temperature and 500°C, and for a time of between about 1sec and 300sec.

1 14. The method of claim 1, wherein the an integrated value of the first concentration of  
2 incorporated nitrogen is between about 1E14 per cm<sup>2</sup> and 3E15 per cm<sup>2</sup>.

1 15. The method of claim 1, wherein the exposing to the oxygen containing ambient is  
2 carried out by subjecting the first surface under thermal conditions to species selected  
3 from the group consisting of O<sub>2</sub>, O<sub>3</sub>, H<sub>2</sub>O, NO, N<sub>2</sub>O, and combinations of these species  
4 thereof.

1 16. The method of claim 15, said thermal conditions are selected to be a temperature  
2 between 500°C and 700°C applied for between 1 minute and 30 minutes.

1 17. The method of claim 1, wherein the exposing to the oxygen containing ambient is  
2 carried out by subjecting the first surface to an oxygen containing plasma.

1 18. The method of claim 17, wherein the oxygen containing plasma is being applied with  
2 a power of between about 25W and 1000W, at a temperature of between about room  
3 temperature and 500°C, and for a time of between about 1sec and 300sec.

1 19. The method of claim 1, further comprising the step of cleaning the first surface before  
2 the incorporating of the first concentration of nitrogen, wherein the cleaning comprises at  
3 least one application of an oxidation and oxide removal cycle, wherein the oxidation is  
4 accomplished with an H<sub>2</sub>O<sub>2</sub> containing solutions, and the oxide removal is accomplished  
5 by a stripping agent, wherein the stripping agent is HF, HCl, or their mixture thereof.

1 20. The method of claim 1, wherein the first surface is having at least two locations, and  
2 wherein the step of incorporating the first concentration of nitrogen is carried out on the  
3 at least two locations in a manner to yield differing first concentrations of the  
4 incorporated nitrogen, whereby the produced germanium oxynitride layers on the least  
5 two locations have differing EOT.

1 21. A method for fabricating a high performance Ge-based field effect device, wherein  
2 the device comprising a germanium oxynitride gate dielectric, and production of the  
3 germanium oxynitride gate dielectric is comprising the steps of:

4 incorporating a first concentration of nitrogen into a surface layer underneath a  
5 first surface of the Ge-based material; and

6 inducing growth of the oxynitride layer by exposing the first surface of the Ge-  
7 based material to an oxygen containing ambient, wherein the first concentration of  
8 nitrogen in the surface layer is controlling the growth of the oxynitride layer.

1 22. The method for fabricating of claim 21, wherein the high performance Ge-based field  
2 effect device is a Ge MOS transistor.

1 23. The method for fabricating of claim 21, wherein the germanium oxynitride gate  
2 dielectric has between 0.5nm and 5nm of EOT.

1 24. A Ge-based field effect device, comprising:  
2 a germanium oxynitride gate dielectric with less than 6nm of EOT.

1 25. The Ge-based field effect device of claim 24, wherein the germanium oxynitride gate  
2 dielectric has between 0.5nm and 5nm of EOT.

1 26. The Ge-based field effect device of claim 24, wherein the germanium oxynitride gate  
2 dielectric possesses greater resistance against charge tunneling than a SiO<sub>2</sub> gate dielectric,  
3 meanwhile a capacitance per unit area of the germanium oxynitride gate dielectric is at  
4 least as large as the capacitance per unit area of the SiO<sub>2</sub> gate dielectric.

1 27. The Ge-based field effect device of claim 24, wherein the device is a Ge MOS  
2 transistor.

- 1           28. A high performance processor, comprising:
- 2                     at least one chip, wherein the chip comprises at least one Ge-based field effect
- 3           device, and wherein the device comprising a germanium oxynitride gate dielectric with
- 4           less than 6nm of EOT.
- 1           29. The high performance processor of claim 28, wherein the processor is a digital
- 2           processor.
- 1           30. The high performance processor of claim 28, wherein the processor comprises at least
- 2           one analog circuit.